Web-PST

Web-based Pesticide Screening Tool

By

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Abstract

We have developed a web-based software tool for evaluating the potential risk of pesticides on the surrounding environment. The software tool is called **Web-based Pesticide Screening Tool (Web-PST)**. It uses the formulas and standards specified by the **Soil/Pesticide Interaction Screening Procedure Version II (SPISP II)**. Web-PST closely models the stand-alone Windows application **Windows Pesticide Screening Tool (WIN-PST)**. For a given pesticide, a soil type, and a cultivation practice, **Web-PST** evaluates the likelihood of pesticide loss and its potential risks to both humans and fish. In addition to hazard ratings, **Web-PST** allows the user to generate a list of pests that can be controlled with a given pesticide. It also generates a list of the types of agricultural situations where the pesticide is commonly applied.

Keywords and Phrases: Pesticide, solubility, leaching, pesticide screening, chemical toxicity, hazard rating.

INDEX

1. Introduction 5
2. Background 6
   2.1 Overview of WIN-PST 7
3. System Overview
   3.1 System Architecture 8
   3.2 Functions of Web-PST 9
   3.3 Data Model of Web-PST 10
   3.4 Features 11
4. Basic Definitions 13
5. Database 16
6. Implementation
   6.1 Soil Algorithms 25
   6.2 Pesticide Algorithms 28
   6.3 Interaction Algorithms 31
   6.4 Toxicity Algorithms 33
   6.5 Exposure Ratings 34
   6.6 Hazard Ratings 35
7. Summary and Future Work
   7.1 Summary 36
   7.2 Future Work 37
8. References 38

Appendix A. Screen shots
   Selecting Soil 39
   Selecting Pesticide 40
   Generating Report 42

Appendix B. Database Queries 43

1. Introduction

Long-term environmental impacts of modern farming practices cannot be ignored. For quite some time, researchers have been working on a rating system that could standardize the risk assessment from pesticide use. The US Department of Agriculture's Natural Resources Conservation Service (NRCS) and Agricultural Research Service (ARS) developed a screening procedure to evaluate the potential risk of pesticide loss from the soil, it is called **Soil and Pesticide Interaction Screening Procedure Version I (SPISP I)**. SPISP I was followed by the development of the **Soil and Pesticide Interaction Screening Procedure Version II (SPISP II)**. These new standardized documents served as a guideline for a Windows-based software tool developed by USDA and National Water and Climate Center (NWCC). This tool was called **Windows Pesticide Screening Tool (WIN-PST)**.

WIN-PST uses qualitative ratings to classify the relative likelihood of pesticide loss. Pesticide loss occurs from field boundaries via runoff and from below the root zone via percolation. The interaction rating is based on the two separate ratings one for soil types and the other for pesticides. The rule based algorithms developed by Don Goss and R. Don Wauchope, are used to determine the rating for each combination of a soil type and a pesticide [Ref.1]. The basic ratings are then adjusted by case-specific conditions, namely rate of pesticide application, slope of the field and probability of precipitation. The interaction ratings thus generated are used along with the pesticide toxicity data to calculate the level of hazard or risk from its application. The risk factor is assessed and rated into four classes: HIGH, INTERMEDIATE, LOW and VERY LOW.

The estimated pesticide losses are categorized into leaching, adsorbed runoff, and solution runoff. Algorithms using soil properties and pesticide properties group the soils and pesticides separately into three or four loss potentials for each loss category. The soil and pesticide loss potentials are then combined in a matrix to give an overall loss potential for each loss category. This overall loss potential for each category combined with the toxicity data of the pesticide is used to generate the hazard rating.

Over the next few sections we shall talk about WIN-PST, we shall discuss the working of Web-PST, explain the soil-pesticide database, and review the pesticide screening algorithms.

Considering the continued growth of the Internet, we created a pesticide-screening tool for the Internet, and called it **Web-Based Pesticide-Screening Tool (Web-PST)**. It is based on the algorithms contained in the SPISP II document, and closely follows the structure of WIN-PST.

2. Background

Tools such as Windows Pesticide Screening Tool (WIN-PST) and National Agricultural Pesticide Risk Analysis (NAPRA) help farmers and conservation planners analyze the environmental risks associated with pest management. These tools have been designed to help assess the risks of offsite pesticide movement from agricultural fields. The goal of the Natural Resources Conservation Service (NRCS) pesticide risk analysis tools is to help

- Identify potential environmental risks
- Efficiently apply mitigation strategies

Risk analysis tools are classified into Tiers based on their limitations and strengths. The tier system is more like a guideline than actual steps. A tier is a generalization of the complexity of the tool that is based on its ability to account for multiple variables and the flexibility of its results. The skill level and time needed to complete a risk analysis increases with each tier. Tier I tools take into account a small set of important variables such as pesticide half-life or soil erodibility factor. An example of a Tier I tool would be WIN-PST. Tier II provide more detailed evaluation of management practices. NAPRA is an example of a Tier II tool. Tier III tools utilize site-specific inputs. Generic soil and pesticide properties replace field measured data and individual producer records. **Ground Water Loading Effects of Agricultural Management Systems (GLEAMS)** is as example of a Tier III tool.

2.1 Overview of WIN-PST

WIN-PST was designed to evaluate the potential for off-site pesticide movement through runoff, leaching, and erosion. Both soil and pesticide properties were considered by its screening procedure. In addition to the properties, basic management techniques and pesticide toxicities were also included in WIN-PST. WIN-PST was originally designed as a Tier I screening tool. The inclusion of pesticide toxicity and management practices applied in the field, which are input variables of Tier II tools, has resulted in WIN-PST being designated a Tier 1.5 tool. WIN-PST was used for the following purposes.

- To identify vulnerable areas of watersheds or other areas as targets for detailed planning.
- To screen high versus low pesticide pollution risks on a field-by-field basis.
- To plan appropriate mitigation strategies on a field-by-field basis.

The SPISP II standard was developed mostly through a stepwise regression approach to select the soil and pesticide parameters that were most heavily weighted for estimating each category of pesticide loss. The screening procedure consisted of three categories:

- Solution Runoff Potential
- Adsorbed Runoff Potential
- Leaching Potential

The group ranking of soils and pesticides under the above mentioned categories do not have an absolute definition relative to quantity. Pesticide loss potentials reflect only the relative ability of the soil to retain the pesticide. The performance of a soil type and a pesticide are segregated into four groups:

- HIGH
- INTERMEDIATE
- LOW
- VERY LOW (Only for Leaching Potential)

3. System Overview

In this section we describe the architecture of Web-PST and explain how its components work. Web-PST is organized as shown in Figure 1 below.

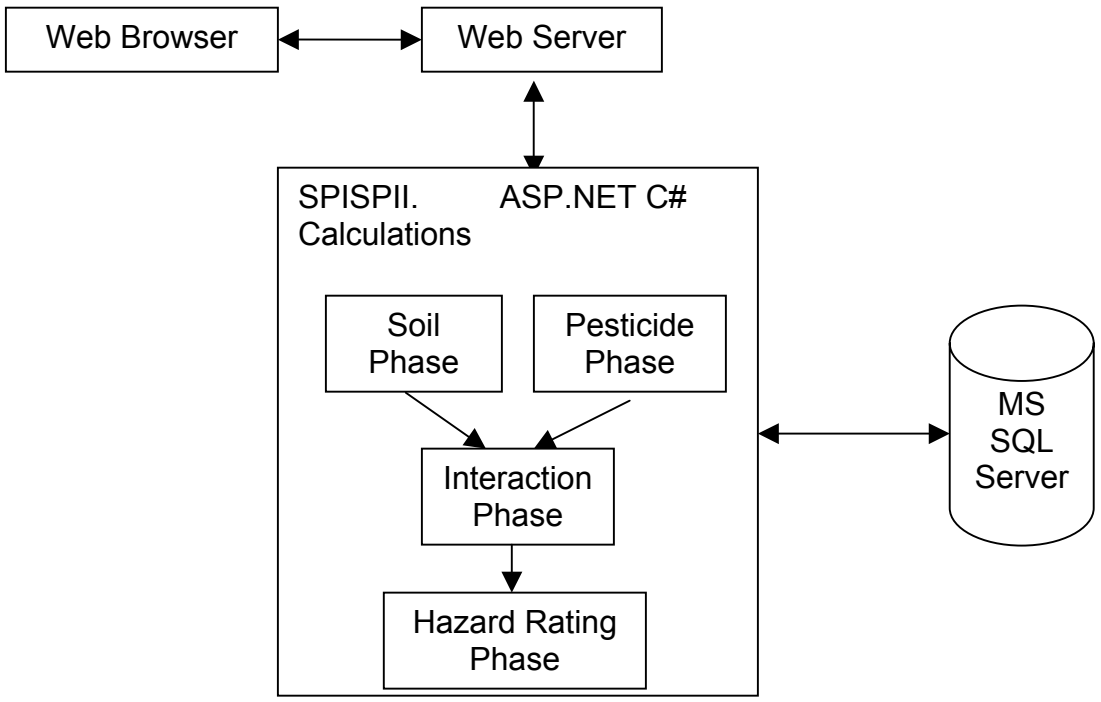


Figure 1. System Architecture of Web-PST.

3.1 Architecture

There are three components to the Web-PST tool:

- Web Interface: Navigating around the tool's web interface is simple. Links to all the major pages have been included in the header frame. A color-coded scheme lets the user know which page is currently active. The shallow design of the web interface aids the usability of the tool. We developed the web interface using ASP.NET, which is a part of Microsoft's .NET framework. Besides the ASP.NET dynamically generated web pages .NET provides modules that allow the interface to connect to the database and map services.

- Web server: All the computations and analyses are done on the server side and the results returned to the client browser. Microsoft's IIS Version 4.0 is used to implement the server.
- Database: The database includes the soil and pesticide data. It was primarily designed for the development of the WIN-PST, but due to the success of WIN-PST, it has been used in many other similar projects. The pesticide database was developed by a group of researchers from National Agricultural Chemicals Association (NACA), US Department of Agriculture Natural Resources Conservation Service (USDA-NRCS), US Department of Agriculture Agricultural Research Source (USDA-ARS), US Department of Agriculture Soil Conservation Service (USDA-SCS), US Environmental Protection Agency (US-EPA), Forest Services and industry members. We decided to use the original design of their pesticide data since it is frequently updated and the updates are available for download over the Internet.

The factors used in pesticide risk analysis include soil characteristics (organic matter, water table depth, water holding capacity), pesticide properties (toxicity, solubility, affinity for organic matter), management factors (application rate, application method, residue management) and climate (rainfall, irrigation).

3.2 Functions of Web-PST

Following are the methods of WIN-PST that implement the pesticide screening algorithms.

- BINDSOILGRID: Is a method implemented on the code behind page soilData.aspx.cs. The loss potential ratings for the soil type selected by the user are generated by this method.
- BINDAIGRID: Is a method implemented on the code behind page pesticidedata.aspx.cs. The loss potential ratings for the pesticide selected by the user are generated by this method.

- BINDINTGRID: is a method implemented on the code behind page InteractionReport.aspx.cs. It combines the loss potential ratings for the soil type and pesticide into the Interaction ratings.
- BINDHAZRADGRID: Is method that combines the interaction ratings with the adjusted exposure ratings to generate the hazard ratings.

3.3 Data Model of Web-PST

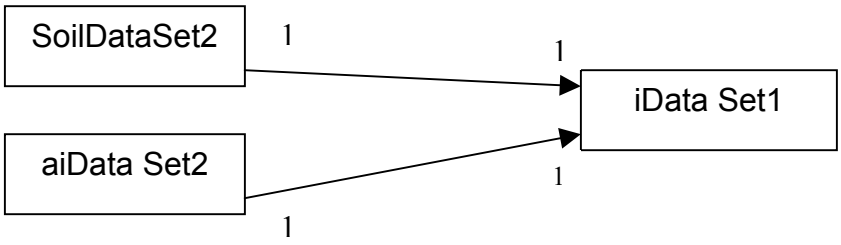


Figure 2. Data Model.

Following is a list of the data sets implemented in Web-PST:

- **aiDataSet1:** is used to populate the active ingredient drop-down list.
- **aiDtaset2:** holds the result of the pesticide query and the PSRP, PARP and PLP loss potentials for the selected active ingredient.
- **soilDataSet1:** populates the soil type drop-down list.
- **soilDataSet2:** holds the results of the soil type query and the SSRP, SARP and SLP loss potentials for the selected soil type.
- **iDataSet1:** soilDataSet2 and aiDataSet2 are combined into aiDataSet1. It also stores ISRP, IARP, ILP, exposure ratings and hazard ratings.

Additional Features of Web-PST

The original WIN-PST database has been extended to include the classification data of the pests that can be controlled by a given pesticide. In addition to generating the hazard report, Web-PST can also be used to list the most common agricultural situations of pesticide use.

3.4 Web-PST Feature Outline

Having taken a look at the system design of Web-PST we shall now discuss its working. The Figure 3 depicts the chronological order of the steps of the screening procedure. (Appendix A contains the screen shorts summary of Web-PST. Web-PST is split into four phases).

Phase 1: The user needs to select the soil type and the conditions prevalent for a field. The following actions are performed during this phase:

- Soil properties are retrieved from the database.
- SSRP, SARP and SLP are evaluated.
- Depending on the applicable conditions, the loss potential ratings are adjusted.

Phase 2: The user needs to select the pesticide that is applied on the field. After having selected the pesticide he is required to select the active ingredient of that pesticide. The user also needs to provide information on the pesticide application technique. The following actions are performed during this phase.

- Chemical properties of the pesticide are retrieved from the database.
- PSRP, PARP and PLP are evaluated.
- Depending on the way the pesticide is applied, the three loss potential ratings are adjusted.

Phase 3: The user is required to provide the climatic conditions of the field at the time of pesticide use.

- Interaction ratings for the three categories are evaluated.
- Depending on the field management conditions, the interaction ratings are adjusted.

Phase 4: There is no user input during this phase.

- The toxicity data for the pesticide selected in phase 2 is retrieved.
- Exposure ratings for fish and humans are calculated and adjusted.
- Interaction and exposure ratings and combined into hazard ratings.

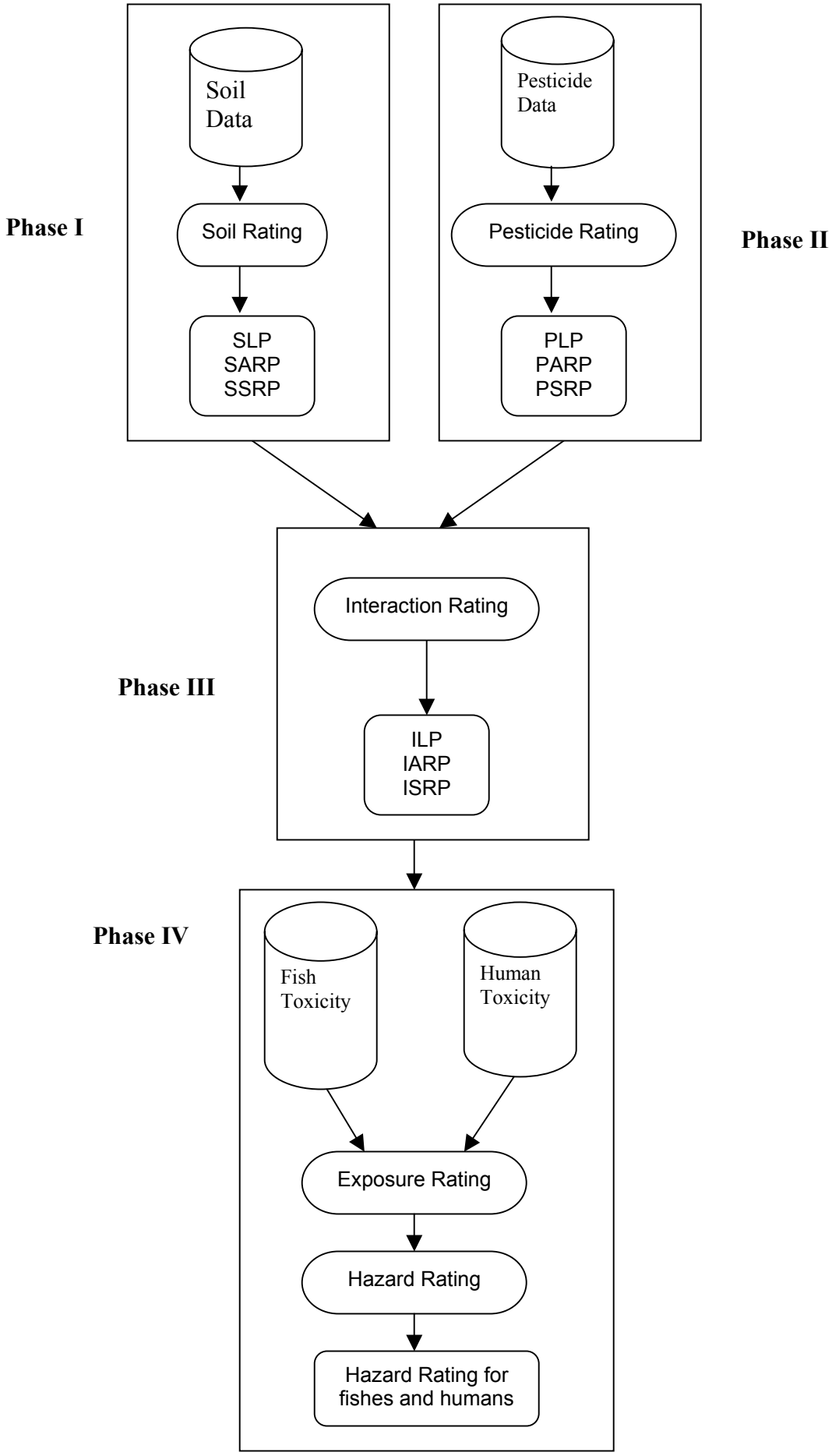


Figure 3. Working Model of Web-PST.

4. Basic Definitions

Before we take a look into the algorithms employed by the screening procedure, we would like to talk about some basic terminology. Web-PST database contains information on a number of selected soil and pesticide properties. Each selected property had an effect on the pesticide retention capacity of the soil. The soil properties picked were representative of a wide range of soils. While the pesticide properties included in the pesticide properties database where chosen as they characterized the chemical composition of the pesticide.

Following is a list of the soil characteristics.

Organic matter content of the surface horizon: Soil organic matter is the organic fraction of the soil that includes plant residue and microbial biomass at various stages of decomposition.

Surface texture: This is a USDA assigned classification, where each soil belongs to a texture class. (ex: **COS** stands for coarse sand).

Soil hydrologic group: It is a group of soils having similar runoff potential under similar storm and cover conditions. The hydrologic group of a soil is designated by characters from **A** to **D,** where **A**, **B**, **C** and **D** stand for the following:

- Low runoff, high percolation
- Moderate runoff and percolation
- High runoff and low percolation
- High runoff and very low percolation

Soil K factor: K-factor is the rate of soil loss per rainfall erosion index unit as measured on a unit area. And is also known as **Soil Erodibility Factor**. A unit plot is 72.6 feet in length, 6 feet in width, has a 9% slope and is continuously in a clean-tilled fallow condition with the tillage performed up-slope and down-slope.

Following is a list of pesticide characteristics that affect pesticide movement.

Product Name/ Common Name: Product name is the manufacture's name for the pesticide and also known as the trade name.

Active Ingredient Name: The active ingredient is that part of the pesticide that provides control over the pest.

Water Solubility: Solubility may be defined as the amount of pure active ingredient that dissolves in water at room temperature. Solubility is a fundamental physical property of a chemical that affects the ease of leaching and runoff/washoff through the soil. In general the higher the solubility value, the greater the likelihood of the pesticide moving beyond the area of application.

Soil Half-life: Half-life **i**s the time required for a pesticide in the soil to degrade to one half of its original concentration. It is usually measured in days. Most often the longer the half-life of the pesticide, the greater the potential for the pesticide movement.

Soil Adsorption Index (KOC): It is the measure of the tendency of a pesticide to attach to the surface of the soil particle.

pH: It is the numerical measure of the acidity or hydrogen ion activity of a chemical.

G/E: Indicates the quality of the representative value. For instance consider the pesticide property **SOLUBILITY**, there is a field in the Web-PST database **SOLUBILITY_G/E** which indicates whether the value in the solubility field for that chemical is an estimate E or guess G.

Having covered all the definitions of the important soil and pesticide properties, we now move on to the basic definitions of the ratings that Web-PST generates for soil and pesticide.

Leaching Potential: The leaching potential indicates the tendency of a pesticide to move in solution with water below the root zone.

Solution Runoff Potential: This rating represents the relative potential for a chemical to move in a surface runoff in the solution phase.

Adsorbed Runoff Potential: This rating represents the relative potential for a chemical to move in surface runoff attached to a soil particle.

Interesting point to note here is the fact that leaching potential indicates pesticide movement through layers of soil, while runoff potential is indicative of pesticide movement over the soil surface.

Following are the toxicity computations.

Maximum Acceptable Toxicant Concentration (MATC): MATC is the long-term toxicity value for fish. It is expressed in parts per billion and is determined empirically by performing long-term or life-stage toxicity tests. MATC in Web-PST is used to calculate the following:

- Exposure toxicity rating to fish in solution form, and
- Exposure toxicity rating to fish in pesticide adsorbed to sediment.

Sediment Toxicity Value (STV): STV provides the toxicity rating of a pesticide adsorbed to a detached soil particle leaving the field. It is used in calculating the exposure toxicity rating for fish based on sediment travel beyond the field boundary.

Health Advisory (HA): HA determined by the USEPA, is the concentration of a chemical in drinking water that is not expected to cause any adverse non-carcinogenic effects over a lifetime of exposure within a margin of safety. It is calculated with respect to humans and is used to calculate the exposure toxicity rating for humans.

Exposure Rating for fish based on MATC: It is the soluble pesticide toxicity level for fish. And is used to compute the overall hazard rating for fish.

Exposure Rating for fish based on STV: It is the adsorbed pesticide toxicity level for fish. It is used to compute the overall hazard rating for fish.

Hazard ratings are the result of combining exposure adjusted toxicity ratings with the interaction ratings of a pesticide-soil-type combination. Hazard ratings are indicative of the relative risk to the environment from the use of a given pesticide. Web-PST generates two sets of hazard ratings:

- Hazard ratings for humans
- Hazard ratings for fishes

5. Database ER Diagram

The Web-PST database is designed to store information related to pesticides and soil types. It stores pesticide data such as active ingredients (AI), solubility, half-life (HL), pH and toxicity; and soil data such as texture of the soil, hydrology group (HYDRO), erodibility factor (KFACT) and organic matter content (OM). The database also maintains information on the map units (MUSYM) associated with each soil type and the state soil survey area (SSAID).

The database maintains information on pests that can be controlled using a given pesticide product. The table **Pests** has a many to many relationship with the table **Products**. This reflects the scenario in which a single pesticide can be control the outbreak of more than one pest, and a single type of pest outbreak may be contained using multiple pesticide products.

The table **Products** has a relationship type many to many with table **Sites**. The relationship reflects the possibility of the pesticide being used at multiple sites and each site and a site requiring the application of multiple pesticides. Each product has an active ingredient and data on the active ingredient is stored in the table **Ais**. Most of the time a given pesticide product has one type of active ingredient, but there are cases where in the same pesticide might have a different active ingredient. Hence the many to many relationship between Table **Ais** and table **Products**.

Every active ingredient may be linked to more than one entry in the table **Chemical** depending on classification employed. The three classifications recognized by the Web-PST database are EPA active ingredient registration number (PC_CODE), the chemical abstract service registration number (CAS_NO), and the chemical abstract service registration number (CASRN). This is the reason for the many-to-many relationship between the table **Ais** and the table **Chemical**.

As mentioned above, the table **Chemical** stores the classification data about the chemicals. The **CHEMICALBYPH** table contains the physical and chemical properties like half-life, solubility etc. for a given chemical. A single chemical may be identified

multiple number of times based on the classification system, yet its physical and chemical properties remain the same. Therefore a many to one relationship exist between these two tables.

Every chemical has a fixed toxicity value for non-target species. In the Web-PST database, we have toxicity data for fish and humans. And since a given chemical has the same effect on a given non-target species, we have a one to one relationship between the toxicity tables and the **Chemical** table.

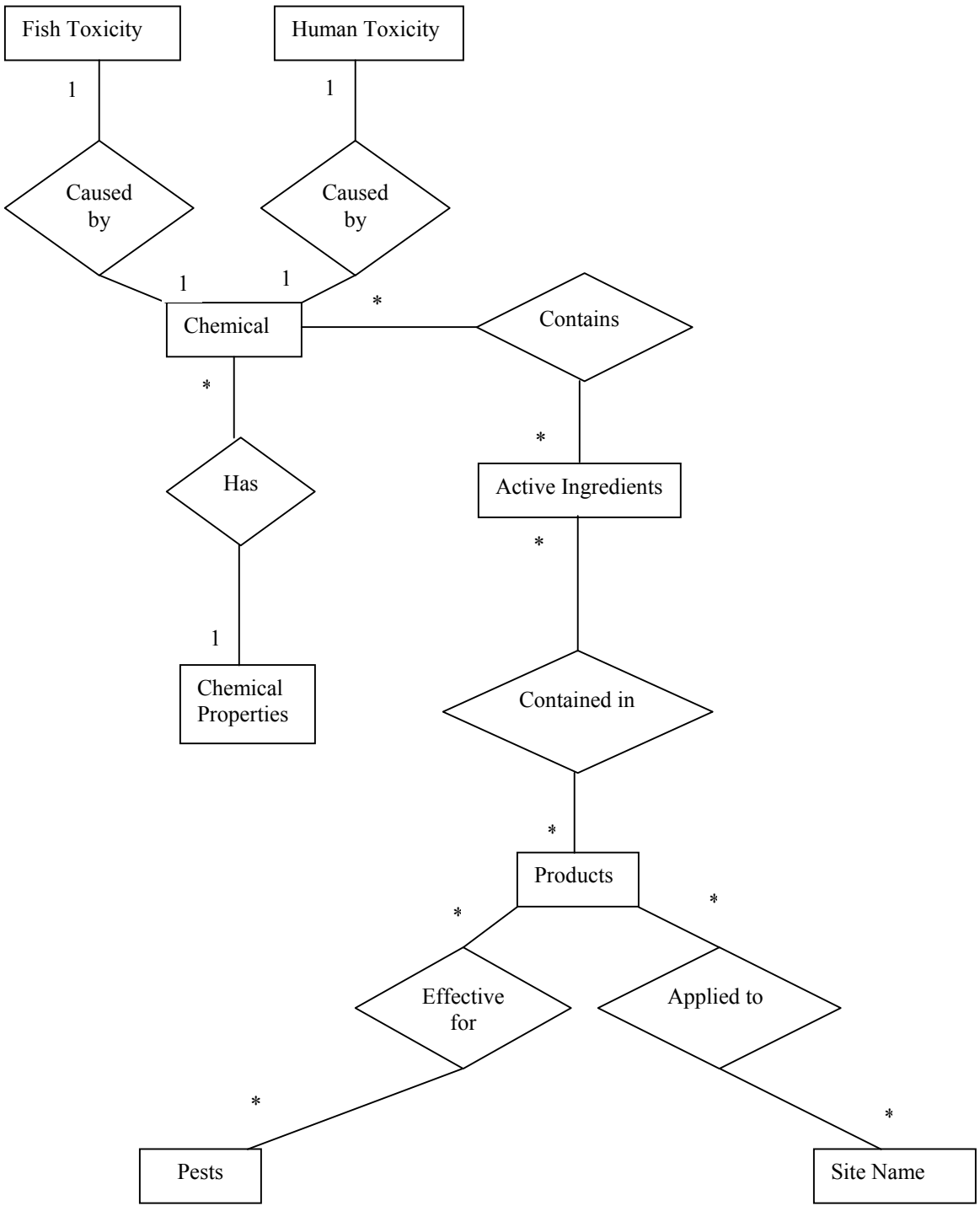


Figure 4. ER Diagram for the Pesticide Database.

The soil table attributes are listed under Table1.

Table 1. Soil Table.		
Column Name	**Data Types**	**Descriptions**
STATE	nvarchar	State to which the field belongs.
SSAID	nvarchar	Soil Survey Area ID
SSANAME	nvarchar	Soil Survey Area Name.
MUSYM	nvarchar	Map unit symbol. It is used to identify the soil.
SEQNUM	float	Sequence number associated with a soil identifying the sequence of components in a map-unit.
COMP_NAME	nvarchar	Name of the component of the map-unit.
TEXTURE	nvarchar	Code for the USDA texture for the specified layer or soil.
PCT_COMP	float	Percentage of soil component.
SLOPE_L	float	The lower range of the slope.
SLOPE_H	float	The upper range of the slope.
WTDEPL	float	Lower range of the depth of high water table.
WTDEPH	float	Higher range of the depth of high water table.
WTKIND	nvarchar	Kind of water table: Apparent, perched or artesian.
HYDRO	nvarchar	Soil hydrology group.
H1_DEPTH	float	Default first horizon depth.

KFACT	float	Soil erodibility factor.
OM_L	float	The minimum value for the range in organic matter content of the soil in percent by weight.
OM_H	float	The maximum value for the range in organic matter content of the soil in percent by weight.
USER_OM	float	% Organic matter content of the soil.
ROCKDEPL	float	The minimum value for the range in depth to bedrock.
ROCKDEPH	float	The maximum value for the range in depth to bedrock.
PHL	float	The minimum value for the range in soil reaction (ph) for the first soil layer.
PHH	float	The maximum value for the range in soil reaction (ph) for the first soil layer.
SHRIKSW	nvarchar	Shrink-swell potential

The fish toxicity table attributes are listed under Table 2.

Table 2. Fish Toxicity.

Column Name	Data Types	Descriptions
CHEMICAL	Nvarchar	Pesticide common name.
CHEM_ID	float	Active ingredient identification number.
CAS_NO	Nvarchar	Chemical Abstract Service Number for an active ingredient.
PC_CODE	Nvarchar	EPA active ingredient registration number.
GT_LT	Nvarchar	Indicates that the actual toxicity is greater than or less than the value listed.

TOX_PPB	Float	Toxic concentration of pesticide in parts per billion
TOX_TYPE	Nvarchar	Toxicity Types available are 96 hour LC50, LOC, MATC* and STV
TOX_TIME	Nvarchar	Time frame associated with the toxicity. Example: MATC: Long Term; LOC: 4 –day.
SOURCE	Nvarchar	Source of data from which MATC* and STV are calculated.
TAXA	Nvarchar	Animal group tested.
NAME	Nvarchar	Common name of the fish species tested.
TAXONOMIC	Nvarchar	Genus and Species of the fish tested.
AGE	Nvarchar	Age of the fish tested.
AI_PERCENT	Nvarchar	Indicates the percentage of a given active ingredient in the product studied.
CALC_NOTES	Nvarchar	A reference to the algorithm used to calculate the toxicity.
STUDY_NAME	Nvarchar	Indicates the actual name used in the study from which pesticide toxicity values were procured.
STUDY_CAS	Nvarchar	CAS_NO reported in the toxicity studies for a pesticide.
STUDY_PC	Nvarchar	PC_CODE reported in the toxicity studies for a pesticide.
STUDY_TIME	Nvarchar	Indicates the relative time frame of the study.
IMPOTANTDATE	nvarchar	Purely Metadata; helps in keeping track of different versions of the data.

The attributes of the human toxicity table are listed under Table 3.

Table 3. Human Toxicity		
Column Name	**Data Types**	**Descriptions**
CHEMICAL	Nvarchar	Pesticide common name.
CHEM_ID	Float	Active ingredient identification number.
CAS_NO	Nvarchar	Chemical Abstract Service Number for an active ingredient.
PC_CODE	Nvarchar	EPA active ingredient registration number.
TOX_PPB	Float	Toxic concentration of pesticide in parts per billion.
TOX_TYPE	Nvarchar	Toxicity types available are MCL, HA, HA* and CHCL.
TOX_TIME	Nvarchar	Time frame associated with the toxicity. Example: Lifetime or Chronic.
SOURCE	Nvarchar	Source of toxicity data: “OW” is from EPA-OW. “BLANK” is from other sources.
CANCERGRP	Nvarchar	EPA cancer class. Affects HA*.
QSTAR	Float	EPA OPP cancer slope value.
OPPRFD	Float	EPA’s office of pesticide programs reference dose.
WHORFD	Float	World health organization reference dose.
OWRFD	Float	EPA’s office of water reference dose.
EPARFD	Float	EPA assigned reference dose.
STUDY_NAME	Nvarchar	Indicates the name used in the study from which pesticide toxicity values were procured.
STUDY_CAS	Nvarchar	CAS_NO reported in the toxicity studies for a pesticide.
IMPORTANTDATE	Nvarchar	Keeps track of versions of the data.

The attributes of the chemical table are listed under Table 4.

Table 4. Chemical		
Column Name	**Data Types**	**Descriptions**
CHEM_ID	Float	Active ingredient identification number.
CAS_NO	Nvarchar	Chemical Abstract Service Number for an active ingredient.
PC_CODE	Nvarchar	EPA active ingredient registration number.
COMMONNAME	Nvarchar	Common name of the chemical.
FOLI_HL_RV	Float	Representative foliar half-life of an active ingredient.
FOLI_HL_GE	Nvarchar	Indicates the quality of data in the FOLI_HL_RV.
PCT_WASHOF	Float	Wash-off fraction data. It is the amount of pesticide applied foliarly available for wash-off.

The attributes of the ChemByPH table are listed under Table 5.

Table 5. CHEMByPH.		
Column Name	**Data Types**	**Descriptions**
CHEM_ID	float	Active ingredient identification number.
PH	float	Measure of acidity or hydrogen ion activity.
SOL_RV	float	Solubility of an active ingredient in water.
SOL_GE	nvarchar	Indicates the quality of the data in the SOL_RV field.
KOC_RV	float	Soil organic carbon adsorption coefficient.
KOC_GE	nvarchar	Indicates the quality of the data in the KOC_RV field.
SOIL_HL_RV	Float	Time required for a pesticide to degrade to one-half of its original concentration.
SOIL_HL_GE	nvarchar	Indicates the quality of the data in the SOL_HL_RV

The attributes of the Ais table are listed under Table 6.

Table 6. Ais.		
Column Name	**Data Types**	**Descriptions**
AI_NAME	nvarchar	Common name associated with an active ingredient.
PC_CODE	nvarchar	EPA active ingredient registration number.

The attributes of the products table are listed under Table 7.

Table 7. Products.		
Column Name	**Data Types**	**Descriptions**
PROD_NAME	nvarchar	Name of the pesticide product.
REG_NO	nvarchar	Pesticide product registration number.

The attributes of the table “Pestsname” are listed underTable 8.

Table 8. Pestname		
Column Name	**Data Types**	**Descriptions**
PEST_CODE	Nvarchar	Primary key to the pestname table.
PEST_DESC	Nvarchar	Description of the insect.
PORDER	Nvarchar	Contains the order of the insect.
FAMILY	Nvarchar	Contains the family of the insect.
GENUS	Nvarchar	Contains the genus of the insect.
SPECIES	Nvarchar	Contains the species of the insect.
COMMONNAME	Nvarchar	Contains the common name of the insect.
CATEGORY	Nvarchar	Part of the plant that is attacked.
KGID	Nvarchar	ID# for the Ken Gray collection.
DESCRIP	Nvarchar	Description of the insect.
NAMEDBY	Nvarchar	Biologist who named the given insect.
INSECTURL	Nvarchar	Contains the link to the picture of the insect

The attributes of the table site are listed under Table 9.

Table 9. Site.		
Column Name	**Data Types**	**Descriptions**
SITE_CODE	nvarchar	Primary key of the site table.
SITE_DESC	nvarchar	Description about the site of application.

6. Implementation

In this section we shall talk about the screening algorithms and their implementation. The results from the four phases of Web-PST are shown below in figure 5. The adjusted soil and pesticide ratings are combined to compute the interaction ratings. The interaction ratings are combined with pesticide toxicity data to generate hazard ratings.

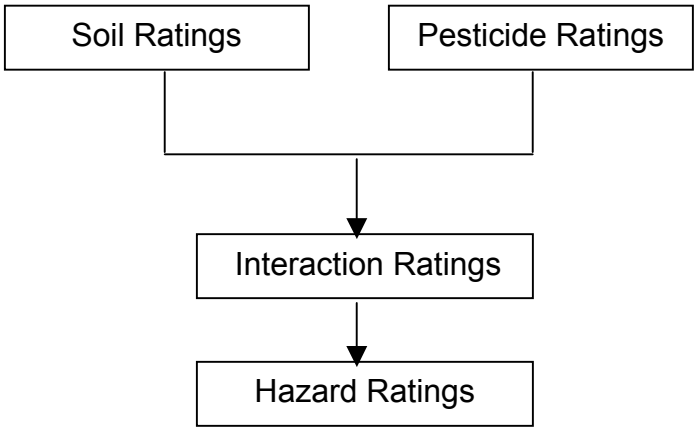


Figure 5. Web-PST Ratings.

6.1 Soil Algorithms

For all soil algorithms, if hydrologic group is "D" and soil erodibility factor (KFACT) is zero, then the default assigned KFACT value is 0.02. This is done to aid the calculations.

Soil leaching potential algorithm (SLP)

```
If ((( HYDRO == A ) and ((( OM * Horizon Depth) <= 30 )) or
(( HYDRO == B ) and ((( OM * Horizon Depth) <= 09 ) and ( KFACT <= 0.48 )) or
(( HYDRO == B ) and ((( OM * Horizon Depth) <= 15 ) and ( KFACT <= 0.26 )) )
   then  SLP = HIGH
else if
((( HYDRO == B ) and ((( OM * Horizon Depth) >= 35 ) and (KFACT >= .40)) or
 (( HYDRO == B ) and ((( OM * Horizon Depth) >= 45 ) and (KFACT >= .20)) or
 (( HYDRO == C ) and ((( OM * Horizon Depth) <= 10 ) and (KFACT >= .28)) or
 (( HYDRO == C ) and ((( OM * Horizon Depth) >= 10 ))
then  SLP = LOW
else if ( HYDRO == D ) then SLP = VERY LOW
else SLP = INTERMEDIATE
```

Soil adsorbed runoff potential algorithm (SARP)

```
If (((HYDRO == C ) and (KFACT >= 0.21)) or
    ((HYDRO == D ) and (KFACT >= 0.10))) then SARP = HIGH
else if ( HYDRO == A ) or
         ((HYDRO == B) and ( KFACT <= 0.10)) or
((HYDRO == C) and (KFACT <= 0.07)) or
((HYDRO == D) and (KFACT <= 0.02))) then SARP = LOW
else SARP = INTERMEDIATE
```

Soil solution runoff potential algorithm (SSRP)

If ((HYDRO == C) or (HYDRO == D)) then SSRP = HIGH
else if (HYDRO = A) then SSRP = LOW
else if (HYDRO = B) then SSRP = INTERMEDIATE

Loss Potential Adjustment

The loss potential adjustments are performed based on the selections made by the user. These conditions are specific to each field site. The soil loss potential ratings generated by the screening algorithms are adjusted using the specific site conditions provided by the user. Figure 6 displays the optional site conditions available.

Figure 6. Site conditions.

Legend

Macropores: Cracks in the surface horizon that have depth greater than 24". This condition is represented in the adjustment matrix by "M".

High Water Table: If the water table comes within six feet of the surface horizon during the growth period, the user needs to check this condition true. "W" denotes it in the adjustment matrix.

Slope greater than 15%: If the slope of the entire field is more than 15% the ratings need adjustment. "S" denotes this condition in the adjustment matrix.

Applicable Conditions	Loss Potential Ratings		
	SLP	SSRP	SARP
M	+1		
W	HIGH		
S			+1
M+W	HIGH		
M+S	+1		+1
W+S	HIGH		+1
M+W+S	HIGH		+1

6.2 Pesticide Algorithms

Pesticide leaching potential algorithm (PLP)

The log( ) function as used here is log, base 10, and log_val = log(HL) * (4 – log(KOC))

```
If ( log_val >= 2.8 ) then PLP = HIGH
else if (( log_val <0.0 ) or (( SOL < 1 ) and ( HL <= 1 ))) then PLP = VERY LOW
else if ( log_val <= 1.8 ) then PLP = LOW
else PLP = INTERMEDIATE
```

Pesticide adsorbed runoff potential algorithm (PARP)

```
If (( HL >= 40 ) and ( KOC >= 1000 )) or
(( HL >= 40) and ( KOC >= 500 ) and ( SOL <= 0.5 )) then PARP = HIGH
else if ( HL<= 1 ) or
        ((HL <= 2 ) and ( KOC <= 500 )) or
        (( HL <= 4 ) and ( KOC <= 900 ) and ( SOL >= 0.5 )) or
        ((HL <= 40 ) and ( KOC <= 500 ) and ( SOL >= 0.5 )) or
        ((HL <= 40 ) and ( KOC <= 900 ) and ( SOL >= 2 )) then PARP = LOW
else PARP = INTERMEDIATE
```

Pesticide solution runoff potential algorithm (PSRP)

```
If (( SOL >= 1 ) and ( HL > 35 ) and ( KOC  < 100000 )) or
   ((SOL >= 10 ) and (SOL < 100 ) and (KOC <= 700 )) then PSRP = HIGH
else if ( KOC >= 100000 ) or
        (( KOC >= 1000 ) and ( HL <= 1)) or
        (( SOL < 0.5 ) and ( HL < 35 )) then PSRP = LOW
else if PSRP = INTERMEDIATE
```

Loss Potential Adjustment

The pesticide loss potential ratings that are generated by the screening algorithms are adjusted using the specific management technique selections provided by the user. The figure7 below displays the optional pesticide management techniques that the screening algorithms account for.

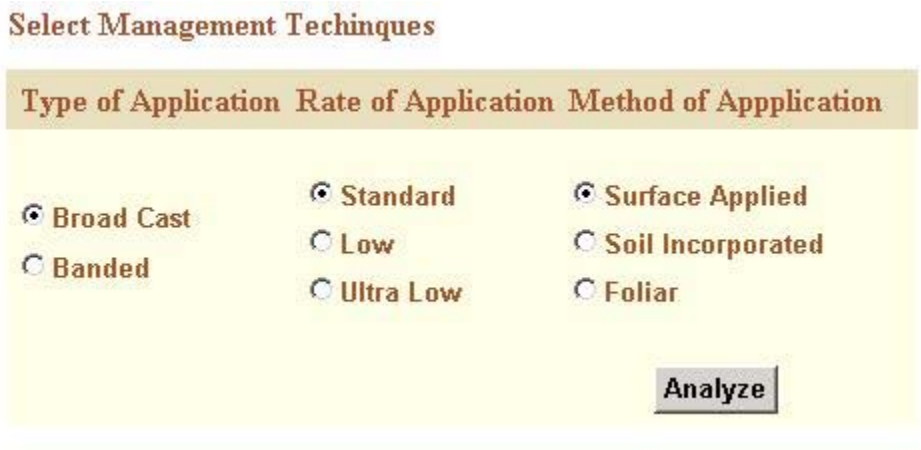


Figure 7. Pesticide Application Techniques

Legend

Type of Application

The SPISP II standard provides accounts for the following two types of pesticide application:

- “B” in the adjustment matrix denotes the broadcast type application.
- Banded is the default selection for the application type.

Rate of Application

The SPISP II standard recognizes the following three rates of application:

- Standard is the default rate of application used by Web-PST.
- “L” in the adjustment matrix denotes a low rate of application.
- “UL” in the adjustment matrix denotes an ultra low rate of application.

Method of Application

The screening algorithms provide for the following three methods of application:

- Surface application is the default method of application.
- “I” in the adjustment matrix denotes soil-incorporated method.
- “F” in the adjustment matrix denotes foliar application method.

Management Techniques	**Loss Potential Ratings**		
	PLP	PSRP	PARP
B	-1	-1	-1
I	+1	-1	-1
F	-1	-1	-1
B+I		-1	-1
B+F	-1	-1	-1
L	-1	-1	-1
UL	-2	-2	-2
B+L	-1	-1	-1
B+UL	-2	-2	-2
I+L		-1	-1
I+UL	-1	-2	-2
F+L	-1	-1	-1
F+UL	-2	-2	-2

B+I+L	-1	-1	-1
B+I+UL	-2	-2	-2
B+F+L	-1	-1	-1
B+F+UL	-2	-2	-2

6.3 Interaction Ratings

Interaction leaching potential matrix

Soil Leaching Potential	**Pesticide Leaching Potential**			
	HIGH	INTERMEDIATE	LOW	VERY LOW
HIGH	HIGH	HIGH	INTERMEDIATE	LOW
INTERMEDIATE	HIGH	INTERMEDIATE	LOW	VERY LOW
LOW	INTERMEDIATE	LOW	LOW	VERY LOW
VERY LOW	LOW	LOW	VERY LOW	VERY LOW

Interaction adsorbed runoff potential matrix

Soil Adsorbed Runoff Potential	**Pesticide Adsorbed Runoff Potential**		
	HIGH	INTERMEDIATE	LOW
HIGH	HIGH	HIGH	INTERMEDIATE
INTERMEDIATE	HIGH	INERMEDIATE	LOW
LOW	INTERMEDIATE	LOW	LOW

Interaction solution runoff potential matrix

Soil Solution Runoff Potential	**Pesticide Solution Runoff Potential**		
	HIGH	INTERMEDIATE	LOW
HIGH	HIGH	HIGH	INTERMEDIATE
INTERMEDIATE	HIGH	INTERMEDIATE	LOW
LOW	LOW	LOW	LOW

Interaction Rating Adjustment based on overall field management technique

The interaction ratings adjustment basically accounts for the climatic other indirect factors that have affect pesticide movement.

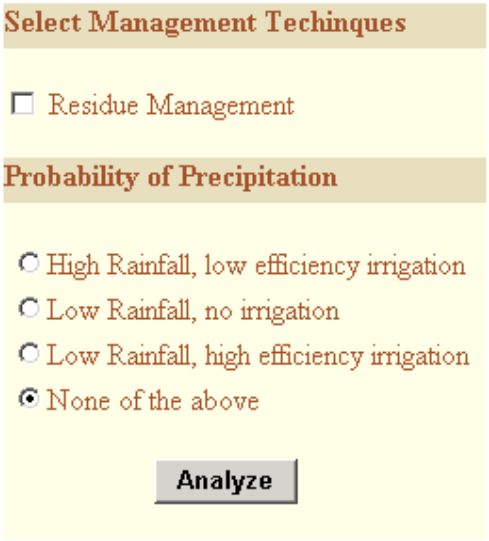


Figure 8. Field Level Management Techniques

Legend

Residue Management: Denotes the existence of a field level program to handle excess or remainder of the pesticide. If the water leaving the field is inactivated and decontaminated before it is allowed to mix with other water bodies outside the field, off-site loss that occurs through soluble and adsorbed pesticide runoff are reduced. “R” in the adjustment matrix denotes residue management practice.

Probability of Precipitation: The probability of precipitation soon after application of pesticide has a considerable effect on the amount of pesticide loss from the site of application. If little or no precipitation occurs a significant loss may not occur. Thus the climatic condition under which the pesticide is applied is crucial to the pesticide movement. The screening procedure provides the following alternatives:

- High rainfall and low efficiency irrigation, which is denoted by “HL”.
- Low rainfall and no irrigation, which is denoted by “LN”.

- Low rainfall and high efficiency irrigation, which is denoted by “LH”.
- None is the default condition that the screening tool works with when the user makes no selection.

Management Techniques	Interaction Ratings		
	ILP	ISRP	IARP
R		-1	-1
HI	+1	+1	+1
LN	-1	-1	-1
LH	-1	-1	-1
R+HL	+1		
R+LN	-1	-1	-1
R+LH	-1	-1	-1

6.4 Toxicity Ratings

Toxicity Equations

Maximum Acceptable Toxicant Concentration (MATC): is expressed in parts per billion. It is the long-term toxicity value for fish.

Level of Concern (LOC): is the acute fish toxicity value determined by dividing the 96-hour LC50 by two.

Sediment toxicity value (STV): is the product of MATC and KOC. STV provides the toxicity of pesticides adsorbed to detached soil leaving the field.

Chronic human Carcinogen level (CHCL): is calculated by using the following formula:

$CHCL = (70 * 10^{-5}) / (2 * QSTAR)$

where

“70” represents the average weight of an adult in the kilograms;

10^{-5} represents the 1 in 100,000 chance of contracting cancer.

"2" represents the average amount of water consumption of an adult in liters.

Health Advisory (HA): The EPA 's method reference dose (RFD) method is used for calculating the health advisory. There is a set hierarchy that is followed in using the reference doses:

- OPPRFD: Office of Pesticide Programs Reference Dose
- EPARFD: Environmental Protection Agency Reference Dose
- OWRFD: Office of Water Reference Dose
- WHORFD: World Health Organization Reference Dose.

With 1 being the first preference and 4 the last choice. All these reference dose values are retrieved from the Humtox table.

QSTAR: QSTAR is a field in the Humtox table. It contains the EPA OPP cancer slope value used to estimate the probability of contracting cancer.

6.5 Exposure Ratings

Exposure ratings for fish are evaluated on two scales:

1. Exposure rating evaluated based on MATC. It is also known as the soluble pesticide toxicity level for fish.

Exposure Adjusted Toxicity Ratings based on MATC for fish.	
EXTRA HIGH	1ppb > X
HIGH	10ppb; > X > 1ppb
INTERMEDIATE	100 ppb > X > 10 ppb
LOW	500 ppb > X > 100 ppb
VERY LOW	X > 500 ppb

2. Exposure ratings evaluated based on STV. It is also known as the pesticide adsorbed to sediment toxicity level for fish.

Exposure Adjusted Toxicity Ratings based on STV for fish.	
EXTRA HIGH	10ppb > X
HIGH	100ppb; > X > 10ppb
INTERMEDIATE	1500 ppb > X > 100 ppb

LOW	20000 ppb > X > 1500 ppb
VERY LOW	X > 20000 ppb

Exposure rating for humans is evaluated based on the HA value computed. It is also known as the soluble pesticide toxicity level for humans.

Exposure Adjusted Toxicity Ratings based on HA for humans.	
EXTRA HIGH	1ppb > X
HIGH	10ppb; > X > 1ppb
INTERMEDIATE	50 ppb > X > 10 ppb
LOW	100 ppb > X > 50 ppb
VERY LOW	X > 100 ppb

6.6 Hazard Ratings

The Web-PST hazard classes were developed to determine the potential hazard from pesticide movement. Evaluating the hazard ratings is the final step for Web-PST. Combing the Web-PST interaction ratings with the exposure adjusted toxicity ratings generates the hazard ratings.

There are three types of hazard ratings generated by Web-PST. The first one is for fish based on STV: the second is for fish based on MATC; and the third is for humans based on HA. The exposure adjusted toxicity interaction matrix shown below is used to combine the exposure ratings for both fish and humans with the soil-type-pesticide interaction ratings.

Exposure Adjusted Toxicity Interaction Rating Matrix.				
Exposure Adjusted Toxicity	**Interaction Rating**			**Hazard Rating**
EXTRA HIGH	+	HIGH	→	EXTRA HIGH
EXTRA HIGH	+	INTERMEDIATE	→	EXTRA HIGH

EXTRA HIGH	+	LOW	→	HIGH
EXTRA HIGH	+	VERY LOW (ILP only)	→	INTERMEDIATE
HIGH	+	HIGH	→	HIGH
HIGH	+	INTERMEDIATE	→	HIGH
HIGH	+	LOW	→	INTERMEDIATE
HIGH	+	VERY LOW (ILP only)	→	LOW
INTERMEDIATE	+	HIGH	→	INTERMEDIATE
INTERMEDIATE	+	INTERMEDIATE	→	INTERMEDIATE
INTERMEDIATE	+	LOW	→	LOW
INTERMEDIATE	+	VERY LOW (ILP only)	→	VERY LOW
LOW	+	HIGH	→	LOW
LOW	+	INTERMEDIATE	→	LOW
LOW	+	LOW	→	LOW
LOW	+	VERY LOW (ILP only)	→	LOW
VERY LOW	+	HIGH	→	VERY LOW
VERY LOW	+	INTERMEDIATE	→	VERY LOW
VERY LOW	+	LOW	→	VERY LOW
VERY LOW	+	VERY LOW (ILP only)	→	VERY LOW

7. Summary and Future Work

7.1 Summary

Web-PST does not give numerical estimates of the ground or surface water contamination. It only gives an estimate of the potential for contamination from pesticide

movement. Web-PST can be used either in planning or in response to an identified pesticide affecting a water resource. Hazard ratings produced by Web-PST were identical to those generated by WIN-PST. This fact verified the correct implementation of the screening algorithms.

7.2 Future Work

Most of the future work on Web-PST is dependent on the advancement of the screening procedure. Some of features that might be added to Web-PST are as follows:

1. Transport beyond the root zone and the field edge may be included in the future revisions of the algorithms.
2. Environmental factors such as soil pH, microbe count, and total surface area could be included in the revised algorithms.
3. A major improvement could be to subdivide the range of rate of application into more categories.
4. Considering the crop type is beyond the scope of this screening procedure, its inclusion could help refine the screening procedure.

Future works on Web-PST not dependent on the advancement of the screening procedure, are the following:

1. Results produced by Web-PST may be combined with results produced by other tools such as *Revised Universal Soil Loss Equation* (RUSLE) and *Sediment Total Daily Maximum Loss* (STDML) to generate and generate and more detailed and tighter risk analysis system.
2. Normalizing the soil table to divide the soil survey data and soil type characteristics into separate tables.
3. Allow the user to make multiple selections of pesticide products and soil types so that the hazard ratings for all pesticides used on a field are available in a single report.

8 References

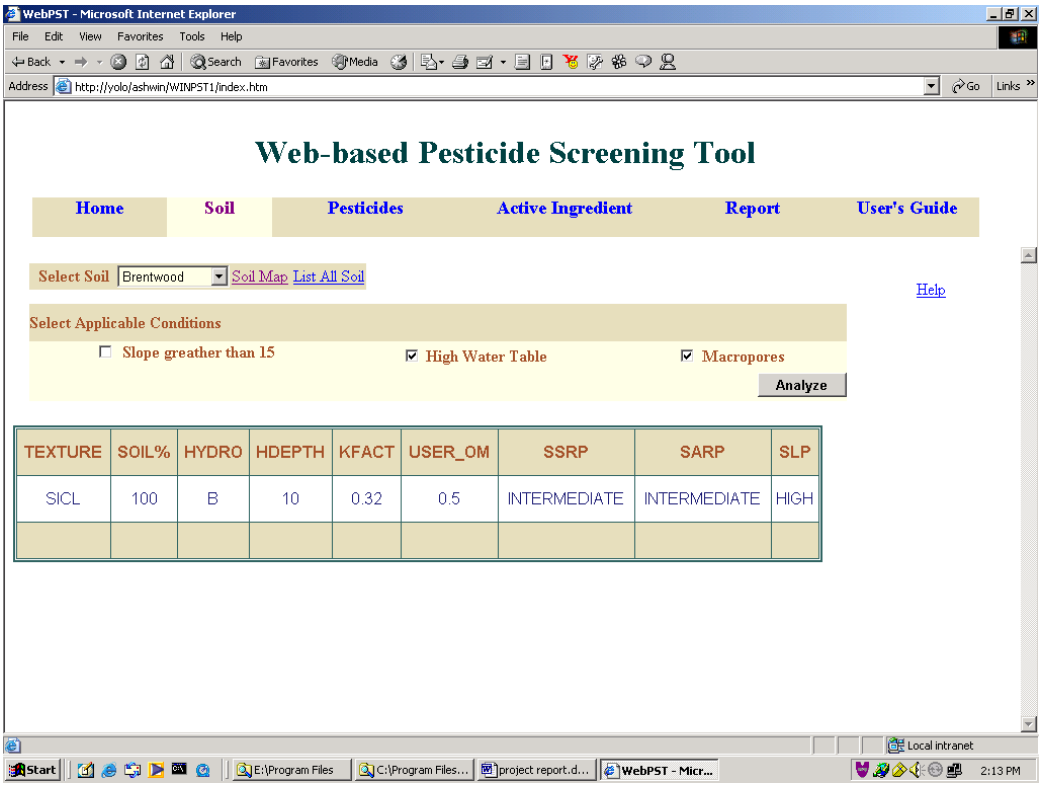
1. Pesticides in the Next Decade: The Challenges Ahead proceedings of the third national research conference on pesticides November 1990 by Don W. Goss.
2. An Evaluation of the Windows Pesticide Screening Tool (WIN-PST) by Da Ouyang The Institute of Water Research Michigan State University October 1999.
3. Techincal Notes on WIN-PST USDA and NRCS September 2001.
4. How to Program in C# by Deitel
5. Beginning ASP.NET using C# Chris Ullman, Chris Goode, Juan T. Llibre, Ollie Cornes.
6. Application Development using C# and .NET by Michael Stiefel and Robert Oberg.

Appendix A: Screen shots

Selecting Soil Type

The user can select the soil type by one the two following methods.

1) Selecting the field on the map
2) Picking out the soil type of the concerned field from the drop down-list.

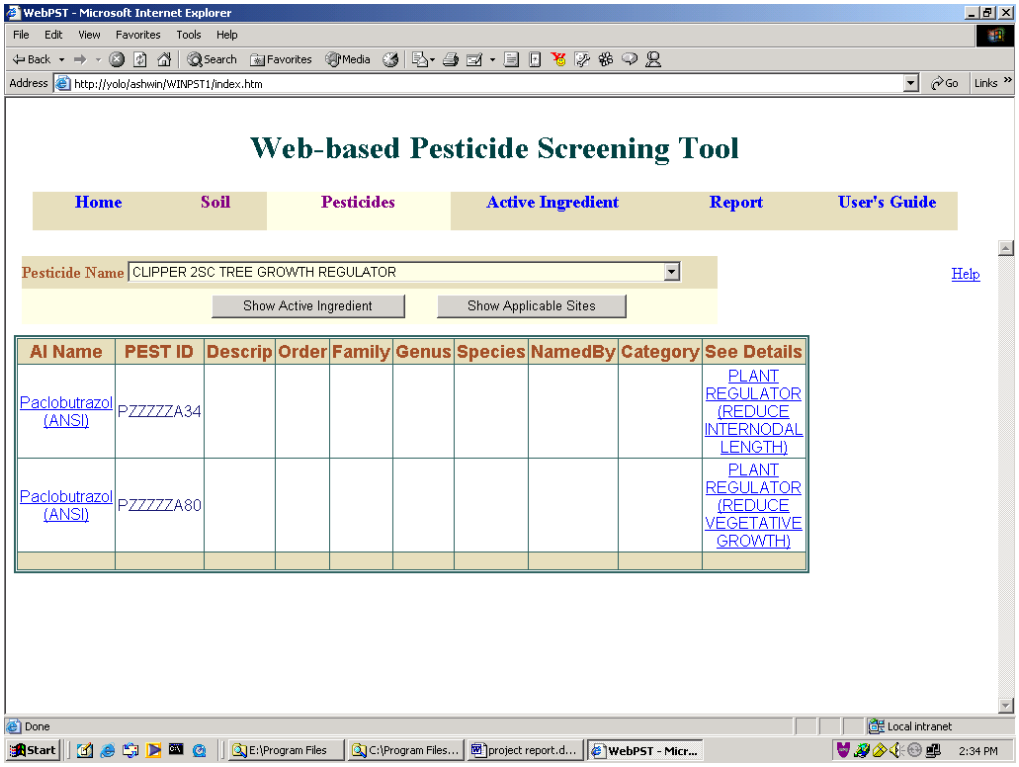


A sample of the soil selection page is shown in Figure# above. The sure has the optional choice of selecting the conditions that are applicable to his field. These form the inputs for Soil Leaching Potential, Soil Adsorbed Runoff Potential and Soil Solution Runoff Potential algorithms. The generated loss potentials along with some of the important soil properties are displayed in a grid for the user to review.

Select Pesticide

The screening procedure uses the active ingredient of a pesticide as the primary input to identify the chemical involved. A given pesticide depending on the manufacturer could have multiple active ingredients. The user on the other hand is only excepted know the pesticide applied. To bridge this gap we provided the user with the option of

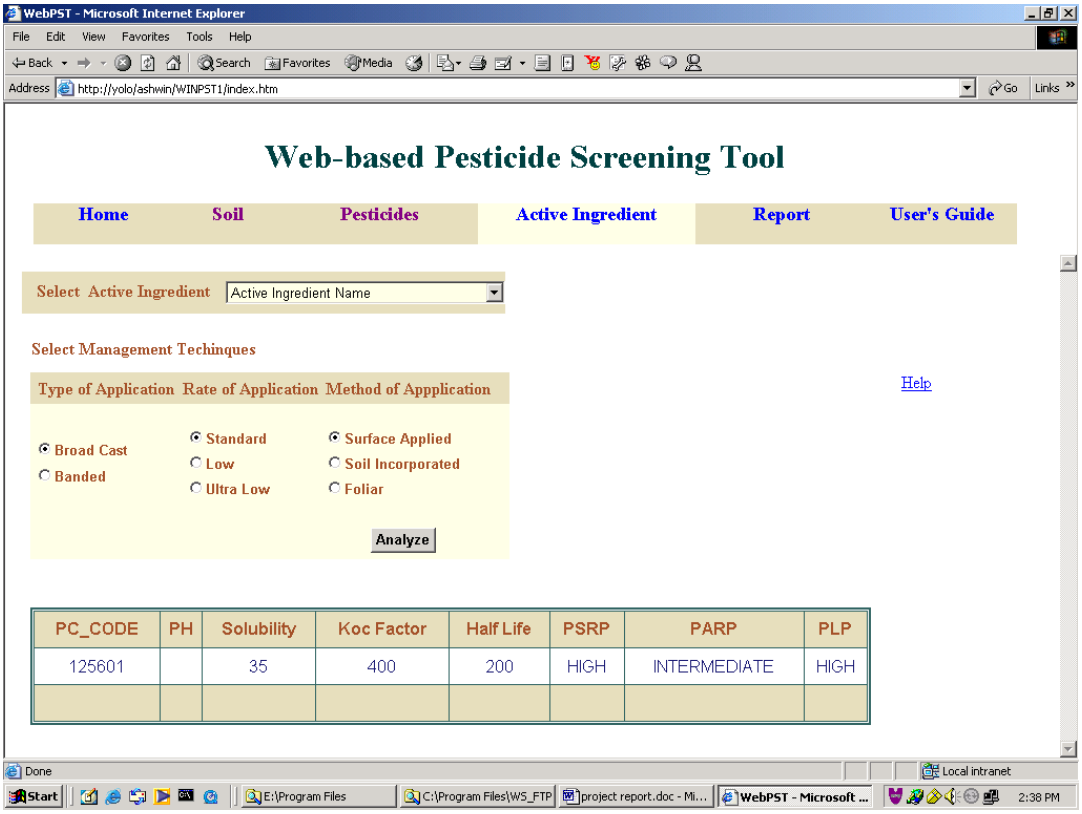
1) Selecting the pesticide and retrieving its active ingredient from the database
2) Selecting the active ingredient directly.



By clicking on “Show Active Ingredient” the user retrieves from the database the active ingredient of that pesticide and the classification information of pests that it can effectively control.

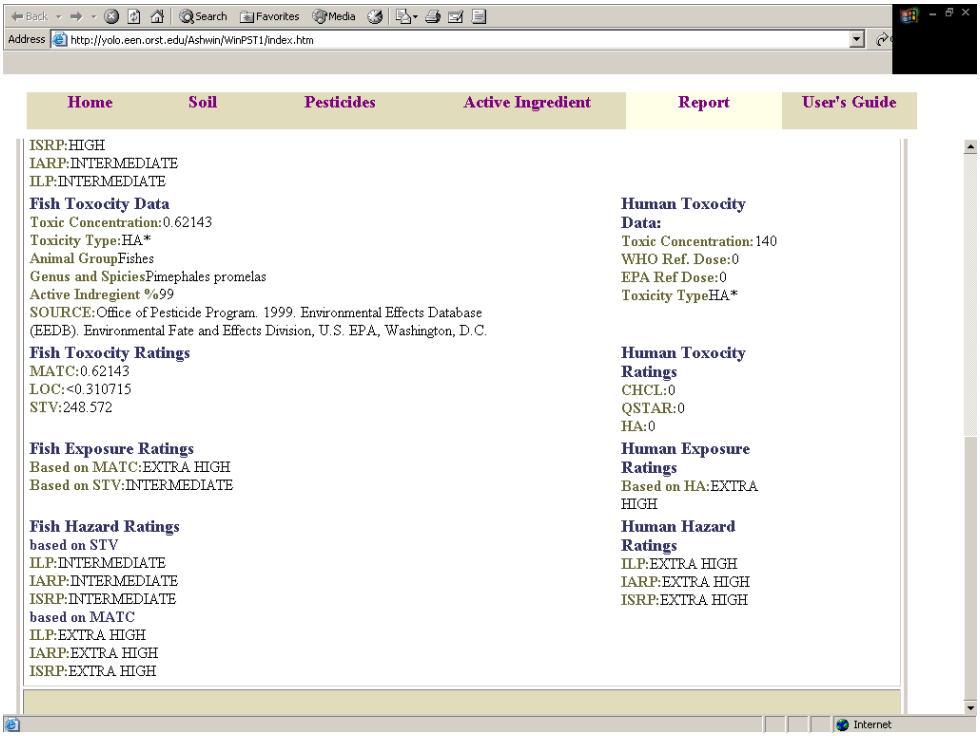
By clicking on “Show Applied Sites” the user can retrieves from the database a list o the common applications of the pesticide.

Select Active Ingredient



By Clicking “Analyze” the user calls the method BINDAIGRID which evaluates the pesticide loss potential ratings.

Generate Report



Appendix B Database Queries

Connection String

datasource=KHONG;initial catalog=heji_winpst;persist security info=False;user

id=Ashwin;password=********;workstation id=KHONG;packet size=4096

Active Ingredient Query

```
Select distinct AI_NAME, Ais.PC_CODE, Chemcas.PC_CODE, Chemcas.CAS_NO,
Chemical.CAS_NO, Chemical.COMMONNAME, Chemical.CHEM_ID,
ChemByPH.CHEM_ID, ChemByPH.PH, ChemByPH.SOL_RV, ChemByPH.KOC_RV,
ChemByPH.SOIL_HL_RV
from Products, Formula, Ais, Chemcas, Chemical, ChemByPH
where AI_NAME like
        if (choice == true)
        {
                " '%" + Request.QueryString["AI_NAME"].Trim() + "%' ";
        }
        else
        {
                " '%" + PesticideDropDownList.SelectedItem.Text.Trim()+ "%'"
        }
        and (Ais.PC_CODE = Chemcas.PC_CODE) and (Chemcas.CAS_NO =
        Chemical.CAS_NO) and (Chemical.CHEM_ID = ChemByPH.CHEM_ID)
```

Toxicity Query

```
Select Ais.AI_NAME, Chemical.COMMONNAME, Fishtox.TOX_PPB,
Fishtox.TOX_TYPE as fishtoxtype, Fishtox.TOX_TIME, Fishtox.TAXA,
Fishtox.TAXONOMIC, Fishtox.AI_PERCENT, Fishtox.SOURCE,Humtox.CANCERGRP,
Humtox.WHORFD, Humtox.QSTAR, Humtox.OPPRFD, Humtox.OWRFD,
Humtox.EPARFD, Humtox.TOX_PPB, Humtox.TOX_TYPE, Humtox.TOX_TIME,
ChemByPH.KOC_RV
from Ais, Chemcas, ChemByPH, Chemical, Fishtox
where AI_NAME like""'%" + pesticidename.ToString().Trim()+"%'" and
(Ais.PC_CODE = Chemcas.PC_CODE) and (Chemical.CHEM_ID =
ChemByPH.CHEM_ID) and (Chemcas.CAS_NO = Chemical.CAS_NO) and
((Chemical.CAS_NO = Fishtox.CAS_NO) and (Chemical.CAS_NO =
Humtox.CAS_NO))
```